# Observations on the Ecology of Four Apogonid Fishes

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THE FISHES of the family Apogonidae are small, inconspicuous creatures which live in and around coral reefs. In the atolls of the central Pacific they are common, occasionally colorful, and sometimes occupants of specialized habitats. This paper reports aspects of the ecology of four species which are uncommon in collections: *Apogon novaeguineae* Valenciennes, which lives among the spines of the sea urchin *Echinothrix diadema* (Linnaeus); *Apogon leptacanthus* Bleeker, which occurs in vast shoals associated with the coral *Montipora gaimardi* Bernard; and *Apogon gracilis* (Bleeker) and *Gymnapogon gracilicauda* Lachner, which school in open water over reefs. Observations were made in the Marshall Islands during the summers of 1950, 1951, and 1955, when the writer participated in research projects sponsored by the Office of Naval Research, the University of Hawaii, and the Pacific Science Board of the National Research Council. Thanks are due these institutions as well as to the Military Air Transport Service and the Atomic Energy Commission who supplied transportation and many facilities. I also wish to thank Mme. I. Catala (Noumea Aquarium, New Caledonia), Dr. D. B. E. Magnus (Zoologisches Institut, Darmstadt, Germany), Dr. C. L. Smith (American Museum of Natural History, New York), Dr. R. A. Stevenson (University of Puerto Rico), and Mr. G. P. Whitley (Australian Museum, Sydney) for supplemental data.

## *Apogon novaeguineae* Valenciennes

Visits were made to a number of atolls in the Marshall and Gilbert groups, but *A. novaeguineae* was found only at Eniwetok in the northern Marshalls. Here it occurred in the lagoon off Parry and Japtan Islands, and on the shallow ocean reef northwest of Cochiti Island. The fish was seen on 33 occasions, 23 times among the spines of the poisonous sea urchin *Echinothrix diadema,* and 10 times nowhere near an urchin. Both the fish and urchins lived in caves or beneath ledges, neither occurring in less than 4-ft depths and most living between about 8 and 18 ft. The number of fish per urchin ranged from 3 to 12, with 4 or 5 being usual.

Another apogonid, *Paramia quinquelineata* (Cuvier) sometimes accompanied *A. novaeguineae* among the urchin spines, while several other species were found in urchins lacking *novaeguineae.* These were *Apogon fraenatus* Valenciennes, *Apogon savayensis* Günther, *Apogon novemfasciatus* Cuvier, and the pipefish *Doryrhamphus m. melanopleura* (Bleeker). The occurrence of these four fishes among urchin spines was uncommon and usually involved only one or two individuals in a particular urchin. The attitude of these spine-dwelling species was horizontal except for *Doryrhamphus,* which oriented parallel to the nearest spines with its head toward the urchin's test.

Most of the above spine-dwelling fishes bear lengthwise stripes, the exception being *A. savayensis.* This is a drab species which neither matches nor contrasts with the urchin and probably occurs among its spines only occasionally. *A. novaeguineae,* on the other hand, is one of the most brightly colored apogonids, and its brilliant yellow contrasts vividly with the black or deep red of the urchin.[2] Its stripes are in-

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[2] A description of the color of living *novaeguineae* could not be found in the literature and therefore is presented here. Ground color of body light yellow, with gold and silver iridescence on sides of head and trunk. Throat and gill membranes white, rest of head yellow with scattered dusky pigment, giving it a dirty appearance. Five narrow white lines on head and body: first from occiput to first dorsal, where it bifurcates and runs along dorsal bases to caudal peduncle; second from interorbital along top of head and trunk parallel to first, uniting with its mate on dorsal edge of caudal peduncle; third from tip of snout across iris,

conspicuous and in no way tend to camouflage the fish.

A number of other fishes have been reported to inhabit sea urchin spines. Most of these bear contrasting stripes or bars which may match the spines in size and color. Such ecological situations have been found elsewhere in the Apogonidae (Abel, 1960*a*:482, 1960*b*:34; Lachner, 1955:43; and Magnus, in press), Gobiesocidae (Briggs, 1955:141; Mortensen, 1940:250; and Pfaff, 1942:413), Centriscidae (Davenport, 1955:37; Herald, 1961:151; and Le Danois et al., 1957:121), and the sciaenid *Eques,* the clinid *Malacoctenus aurolineatus,* the gobiids *Gobiosoma multifasciatum* and *G. novemlineatum,* and the gobiesocid *Acyrtus rubiginosus* (C. L. Smith, personal communication).

Some spine dwellers match the urchin's color but lack stripes. These include the apogonids *Siphamia zaribae* (Whitley, 1959:16), *S. versicolor* (Eibl-Eibesfeldt, 1961:57), several species of the gobiesocid genus *Arbaciosa* (Jordan and Evermann, 1898:2340-2343), some specimens of the gobiesocid *Acyrtus rubiginosus* (C. L. Smith, personal communication), and the Hawaiian pomacentrid *Dascyllus albisella* (R. A. Stevenson, personal communication). Of these, *S. versicolor,* at least, has a changeable color pattern which includes a striped phase. Peculiarly enough, its stripes appear only when the fish is away from its urchin host (Eibl-Eibesfeldt, 1961:58).

Some of the authors mentioned above state that spine dwellers should align their stripes with the spines if their color pattern is to provide an effective camouflage. Apparently this is done by *Paramia bipunctata, Aeoliscus, Doryrhamphus,* and possibly *Diademichthys.* These fishes are thus protected not only by the physical barrier of the spines, but also by the visual barrier of their camouflage. Such a dual safeguard may be necessary if their predators are capable of probing between the spines for food.

The other spine dwellers remain essentially horizontal, and their stripes are usually not aligned with spines. Obviously they are not camouflaged in this position, although the crisscross pattern of lines thus presented may disrupt the fish's outline. It is also possible that color and pattern are of little consequence once the fish is within the spine shelter. Certainly its brilliant yellow color is a blatant advertisement for *A. novaeguineae.*

A few observations were made on *A. novaeguineae* repopulation following departure of the fish from their urchin host. One urchin was removed from its cave and placed on open bottom 4 ft in front of the cave's mouth. A ridge on the bottom prevented the urchin from being seen from the cave. As soon as their host was disturbed, the *novaeguineae* left it and took shelter among the spines of a second urchin in the cave. The exposed urchin was watched for 15 minutes but no fish left the cave to join it. The urchin was then lifted over the ridge and placed 3 ft in front of the cave's mouth. In 2 minutes a single *novaeguineae* swam to the urchin and settled among its spines, followed by a second fish a few minutes later. The urchin crept to the cave's mouth during the succeeding 10 minutes, without being joined by additional fish. Two more *novaeguineae* joined it just as it crossed the cave's threshold. The balance of its original population of fish remained with the second urchin during an additional 5 minutes of observation.

On June 18, 1955, an isolated coral mound containing four large *Echinothrix,* each bearing several *A. novaeguineae,* was heavily treated with rotenone and all of the *novaeguineae* collected. This mound was visited regularly for several weeks, and then less frequently. No *novaeguineae* had returned by July 12, but there were a number of them among the spines of one urchin on August 24. This indicates that *novaeguineae* is rather restrictive in its movements. Unfortunately the distance to the next aggregation was not recorded.

Ten of the rotenoned specimens were examined for food consumed. Of these, two fish were empty and three others (males) had their stomachs packed with embryonated eggs. Probably these fish had been brooding eggs in their mouths and swallowed them under duress. Of

touching upper edge of pupil, thence across midsides to caudal base; fourth from upper lip across iris, touching lower edge of pupil, thence across midsides to end of trunk; fifth from lower lip across suborbital to rear edge of opercle. Lines iridescent blue-white on head but faintly dusky on body. Tip of snout and lips sometimes red-orange. Iris yellow. Pectorals pale, other fins light red.

the five with food in their stomachs, four contained callianassid-like burrowing shrimp, two had ordinary shrimp, one a crab, one contained mysids, and one an unidentified crustacean. Additional food items have been reported by Hiatt and Strasburg (1960:80). None of these food organisms seemed to be an urchin commensal, and therefore it is probable that the fish left their spine shelters to feed. This is not necessary for all spine dwellers, as illustrated by Pfaff's observations (1942:416) of *Diademichthys* feeding on the tube feet of *Diadema* and on the sessile eggs of a shrimp living among the spines. Rivero (1950:115) mentions but does not name certain inquilinistic fishes which feed on colonial hydroids and other invertebrates living on sea urchins, and Eibl-Eibesfeldt (1961:57) describes *Siphamia versicolor* picking at and probably cleaning the test of *Diadema,* which had previously inclined its spines in a possible cleaning posture.

*Apogon leptacanthus* Bleeker

*A. leptacanthus* was found at only one locale, the lagoon side of Uliga Island, Majuro Atoll, Marshall Islands. This apogonid was always associated with the low branching coral *Montipora gaimardi* Bernard. Large growths of *M. gaimardi* were conspicuous at the swimming beach near the Uliga airstrip, and much smaller patches were seen near the Uliga causeway. The water depth over these reefs was 2–6 ft. The fish occurred in sheetlike schools, one or two fish deep, which drifted about 1 ft above the *Montipora* branches. On the approach of a swimmer the school gently subsided into the coral, to emerge after his departure.

The most impressive features of the *A. leptacanthus* schools were the large numbers of individuals and the fact that the environment was quite different from the open-water situation in which schooling usually occurs. The largest school seen was found over a rectangular patch of *Montipora* measuring 60 by 80 ft. About half of this rectangle was occupied by the school, which contained 10–25 fish per sq ft according to numerous estimates. These figures give a school abundance estimate of 24,000–60,000 fish, certainly a remarkable concentration for any reef species. The number of fish in two other schools was estimated in the same way; one contained 2,000–5,000 fish, and the other 500–1,250 fish.

Part of one of the *Montipora* beds was treated with rotenone to determine which other fishes coexisted with such dense concentrations of a single species. The only other fish which could be termed common was *Apogon snyderi* Jordan and Evermann. The following were taken in small numbers: *Chaetodon auriga* Forskål, *C. trifasciatus* Mungo Park, *C. lineolatus* Cuvier, *Thalassoma quinquevittata* (Lay and Bennett), *T. hardwickei* (Bennett), *Holocentrus laevis* Günther, *Parupeneus trifasciatus* (Lacépède), *Plesiops melas* Bleeker, *Ctenochaetus striatus* (Quoy and Gaimard), *Dascyllus aruanus* (Linnaeus), *Abudefduf glaucus* (Cuvier), *Amphiprion melanopus* Bleeker, and *Corythoichthys* and *Gymnothorax* juveniles too small to identify. Such a fauna is typical of most Marshallese coral communities except that here all individuals were small, most being the young of moderate-sized reef fishes. The dense forest of coral branches probably served as a protected nursery area for these small fishes.

The *Montipora* beds were visited on several occasions in 1950, 1951, and 1955. The *A. leptacanthus* schools were always present and, in fact, were regarded as permanent features by Uliga residents. Obviously the nutritional needs of this large population were great. The stomach contents of four rotenoned *leptacanthus* were examined, and revealed their principal food to be crustacean plankters, mostly crab zoea. Presumably these were obtained while the fish drifted above the coral. No *leptacanthus* were seen to feed, but all were noted to head in the same direction, and were probably exhibiting rheotaxic rather than schooling behavior. Currents very probably convey planktonic food to the relatively stationary fish.

A brief color description of *A. leptacanthus* follows: ground color translucent olive-tan, traces of dusky pigment on snout. Iris, suborbital and supraorbital regions iridescent sapphire. Two short diagonal orange bars behind eye, two short vertical orange bars on opercle, and two more on sides above pectorals. A narrow yellow-white line on dorsal midline behind soft dorsal. Pelvics and pectorals reddish, anal with a basal red band and reddish rays. Soft dorsal and caudal rays are faintly reddish.

*Apogon gracilis* (Bleeker) and *Gymnapogon gracilicauda* Lachner

Unlike most Apogonidae, which dwell in close proximity to a sheltering substratum, *A. gracilis* and *G. gracilicauda* are apparently pelagic species. They were observed many times in the lagoon at Parry Island, Eniwetok Atoll, swimming in large, loose schools. Most schools were in the general vicinity of coral mounds at depths of 12–25 ft, but a few occurred over relatively featureless sand or coral rubble at the same depth. The *gracilis* schools were composed of several hundred individuals, whereas the *gracilicauda* schools were much smaller, consisting of perhaps 5–25 fish. The number of schools and the number of fish per school increased with the distance from shore.

Both fish were difficult to recognize as apogonids in life. Their pelagic occurrence was unexpected and their colorless glassy transparency made them hard to detect and characterize. The two could be told apart by the presence in *A. gracilis* of an internal black spot on the lower caudal peduncle and the black tip of its upper caudal lobe.

Morphologically, *Gymnapogon* is quite distinct from the rest of the Apogonidae and it is not surprising to find it occupying a different habitat. A summary of its physical peculiarities and their systematic significance has been presented by Lachner (1953:490). *Apogon gracilis,* on the other hand, is a typical apogonid and shows no particular adaptations to a pelagic mode of life (except possibly for its colorless transparency). The diet of four rotenoned *A. gracilis* consisted of pelagic crustaceans, mostly amphipods.

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